4D FEM models of the human thorax

Ander Biguri and Manuchehr Soleimani

Engineering Tomography Lab (ETL), Electronic and Electrical Engineering, University of Bath, Bath, UK,
a.biguri@bath.ac.uk

Abstract: In order to be able to further study 3D EIT lung imaging and to analyse if the movement of the lungs during the breathing cycle can be reconstructed, accurate FEM models of the whole breathing cycle are needed. In this work we create several FEM models using 4DCT thorax scans of a lung cancer patient. The models will be further used a dual modality EIT-CBCT setup for treatment planning in radiation therapy.

1 Introduction

Electrical Impedance Tomography (EIT) is already used in 2D lung imaging to monitor the breathing cycle. In order to evaluate the feasibility of 3D lung EIT, specially to analyse the information content of the vertical motion of the lungs, accurate geometric models of the thorax and the internal organs in several steps of the breathing cycle are needed. As the effect of the movement is expected to be small, the thorax models need to be as real as possible, in order to ensure that the signal changes that are analysed are going to be present in a clinical scenario.

2 Methods

2.1 4DCT image segmentation

To obtain realistic and accurate geometric information of the human thorax in the breathing process 4DCT images have been used, taken from the open-source DIR dataset [1]. The dataset contains 10 full 3DCT images from maximum inspiration to maximum expiration in normal breathing. To obtain the geometry from the images a simple region growing algorithm has been used, obtaining the whole thorax, the lungs and a tumour. The result of this step is a indexed voxel image. The whole process is shown in figure 1.

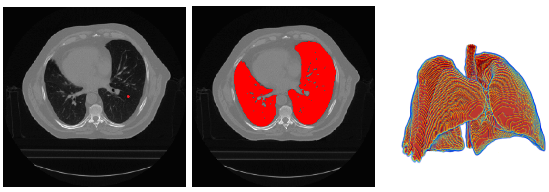

Figure 1: Region growing algorithm. In the left, a seed point specified by the user inside the lungs. In the middle, the expansion of the algorithm with threshold of 20 grayscale intensity. In the right the 3D representation of the result.

2.2 FEM modelling

The meshing of the voxelated image is preformed using the `iso2mesh` [2] mesh generator. This software creates meshes with inclusions from indexed voxel images. As `iso2mesh` does not create electrodes, a code that attach a 1 voxel width electrodes with circular geometry to the thorax has been created, creating volumetric electrodes (unlike the common surface electrodes). One of the frames of the FEM models can be seen compared to the original CT image in figure 2. This FEM models then are saved using the EIDORS data structure. The models have around 300K elements each.

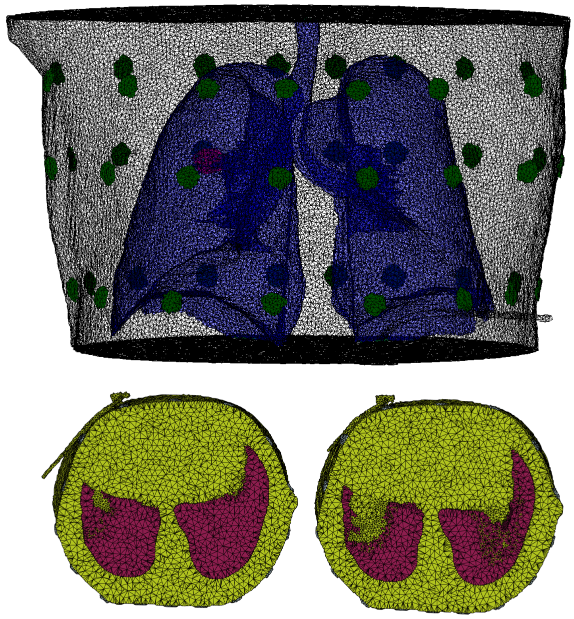

Figure 2: Fine FEM meshes of the human thorax. The top mesh shows the full mesh for the end inspiration instant. It contains 3 rings of 16 electrodes located two of them around the extremas of the lungs and the middle one in the tumour plane. The bottom meshes show the lowest electrode ring plane for end inspiration and end exhalation.

3 Conclusions

The finite element meshes created are an important point for dynamic 3D lung EIT imaging, as they will allow to evaluate realistically the amount of information that can be obtained from 3D lung imaging. While the accuracy of the segmentation has not been evaluated numerically, it is expected to be high, as even the sensor attached to the thorax has been segmented (see bottom part of the models in figure 2). Further analysis of the information content in the vertical axis due to lung motion will be studied further within the group. Additionally in a clinical scenario where the patient had already had a CT scan, this method provides a way of obtaining accurate models in order to reduce the artefacts that may arise due to incorrect geometry when imaging.

4 Acknowledgements

This work is funded by a EPSRC DTA and CERN.

References

[1] Vandemeulebroucke J, Rit S, Kybic J, et al. *Med Phys* **38**(1):166–178, 2011

[2] Fang Q, Boas D. In *Biomedical Imaging: From Nano to Macro, 2009. ISBI '09. IEEE International Symposium on*, 1142–1145. 2009